

Construction and design calculation of parts and elements of RIGID Flange Coupling.

Rigid flange couplings are used to transmit pure torques between two coaxial shafts ends. Accordingly; Casting, machining, assembly and functional considerations are accounted for in the sketches including the different alternatives. The proportions implied by these considerations are also given. The main related standards for the elements are also given.

The following procedure is a typical engineering approach which leads to a reliable, compact and well sized rigid flange coupling. This approach adopts irrational and rational design approaches when needed.

To take into consideration the working conditions of the driven machine, a service factor should be applied to the load to be transmitted.

* SERVICE FACTOR: (K_s)

<div>Daily working hrs</div> <div>Load Classification</div>	up to 4 h	8 h	16 h	24 h
Steady	0.8	1	1.1	1.3
moderate shocks	1.1	1.2	1.4	1.5
heavy shocks	1.4	1.5	1.6	1.7

The values given are suitable for a number of starts per hour ranging from 10 to 200 starts/h.

Design Approach of a Rigid Flange Coupling:

- 1- Calculate, if not known, the shaft end diameter based on transmitted torque, service factor of the driven machine and starting condition:

Starting conditions:

Load factor (K_L)

- * Direct on load 2
- * Star-delta ($\text{Y}-\Delta$) starting 1.732
- * Soft starter:
 - Online hydraulic coupling 1.25
 - Manually controlled clutch 1.5

Margin of safety: applied to torsional yield stress (τ_y)

a factor of $K_m = 1.3$

Service factor: see table for K_s

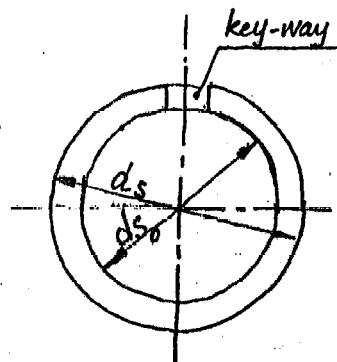
Select a suitable shaft material and hence,

$$\frac{\tau_y}{K_m} \geq \frac{16 T_d}{\pi d_{s0}^3}$$

$$T_d = \frac{71620 \text{ HP}}{n} * K_L * K_s$$

d_{s0} = min. shaft diam.

- From [DIN 748-1] select d_s & l
- (From [DIN 6885-1] Select the key)



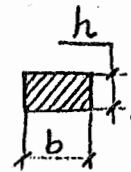
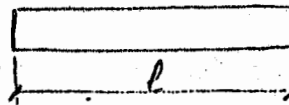
- 2- Based on proportions implied by basic manufacturing considerations, workout the dimensions (and then the details of construction) leading to the nominal bolt size and the pitch circle diameter.

3- Check the key dimensions :

key cross-section = $b \times h$

key length = l

select key material st. 50 OR 60



- Shear strength :

$$\frac{\tau_y}{k_m} = (2T_d / d_s) / (b \cdot l)$$

to find $l \leq 1.5 d_s$

- Crushing stress

$$\sigma_{cr \text{ allowable}} = \left(\frac{400 \text{ B.H.N.} - 10,000}{1.4} \right) \text{ N/mm}^2$$

B.H.N. = Brinell hardness number of the annealed softer material (of the key, the shaft or the coupling hub)

(This formula is empirical)

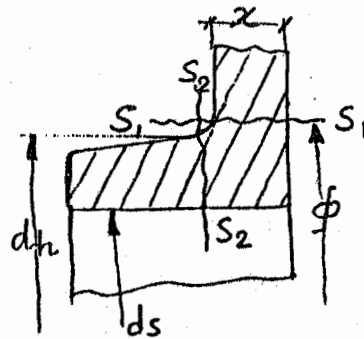
4- Check flange at critical sections:

Section $S_1 - S_1$:

$$\tau_{\text{working}_1} = \frac{(2T_d / \phi)}{\pi \phi x} = \frac{2T_d}{\pi x \phi^2}$$

Section $S_2 - S_2$:

$$\tau_{\text{working}_2} = \frac{16 T_d d_h}{\pi (d_h^4 - d_s^4)}$$



τ_{working_1} and τ_{working_2} should be $< \frac{\tau_u}{2 \times 1.3}$

and hence select the suitable cast iron grade.

For		$\sigma_u \text{ N/mm}^2$	$\tau_u \text{ N/mm}^2$	$\tau_{\text{end}} \text{ N/mm}^2$
GG-15		150	70	50
GG-25		250	120	90
GGG-40		400	190	140

5- Calculate the required number of bolts :-

Note:

The suitable bolt size is already figured out rationally from the construction laid down with reference to the basic manufacturing considerations. Taking into account the suitable bolt material, one can calculate the load which this bolt made of the selected material and of this size can adequately and safely sustain. There are two methods can be adopted to transmit the torque between the two flanges :

either by shear bolts / shear bushes

OR by generating enough friction between flanges.

Depending upon the adopted method of transmitting the torque, the required number of bolts is rationally calculated as follows :

5-1- Shear bolts / shear bushes :

Bolt (Shear bush) material, $\sigma_y = \sqrt{\quad}$ & $\tau_y = 0.6\sigma_y$

Sheared area = A_s

margin of safety = 1.3

i.e. the shearing force the bolt can sustain = P_s

The pitch circle diameter = D_p

\therefore The number of bolts = $\frac{2 T_d / D_p}{P_s}$ where :

$$T_d = T * K_L * K_s \quad \text{and}$$

$$P_s = A_s * \frac{\tau_y}{1.3}$$

The number of bolts should be divisible by 2 (or 3)

5-2- Torque transmission by friction :

a) Bolt nominal diam. = d
 core area = $A = \frac{\pi d_c^2}{4}$, pitch = p
 \therefore mean diam. = d_m

$$\tan \alpha = p / \pi (d_m)$$

$\mu_{thr.}$ = thread friction coefficient

$$\mu' = \frac{\mu_{thr.}}{\cos \beta} , \beta = 30^\circ \text{ (metric thread)}$$

$$\text{Thread friction torque} = T_1 = P_a \frac{d_m}{2} \left[\frac{\tan \alpha + \mu'}{1 - \mu' \tan \alpha} \right]$$

where :

P_a is the axial load in the bolt (by tightening)

$$\text{i.e. } \tau = \frac{16 T_1}{\pi d_c^3} = \left[\frac{16}{\pi d_c^3} \left(\frac{d_m}{2} \right) \left(\frac{\tan \alpha + \mu'}{1 - \mu' \tan \alpha} \right) \right] \cdot P_a$$

$$\text{also: } \sigma = \left[\frac{4}{\pi d_c^2} \right] \cdot P_a$$

$$\therefore \tau_{comb} = \frac{1}{2} \sqrt{\sigma^2 + 4\tau^2} = C \cdot P_a$$

where C is a value already determined.

b) For a selected bolt material, $\sigma_y = \sqrt{\quad}$, $\tau_y = 0.6\sigma_y$

$$\therefore \frac{\tau_y}{\text{margin of safety}} = \frac{\tau_y}{1.3} \geq C \cdot P_a$$

$$\therefore P_a = \sqrt{\quad} = \text{The max. safe load per bolt}$$

c) Friction coefficient between flanges = μ_f

$$\text{Friction ring mean diameter} = D_{fr}$$

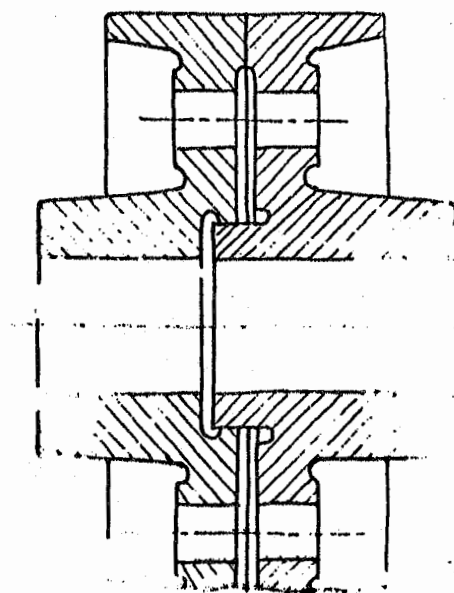
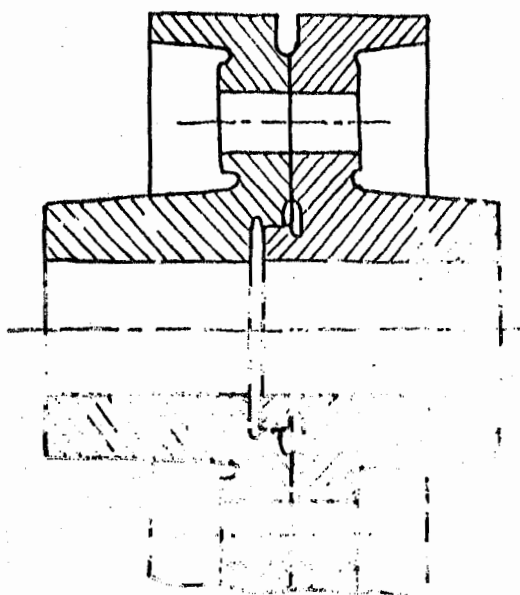
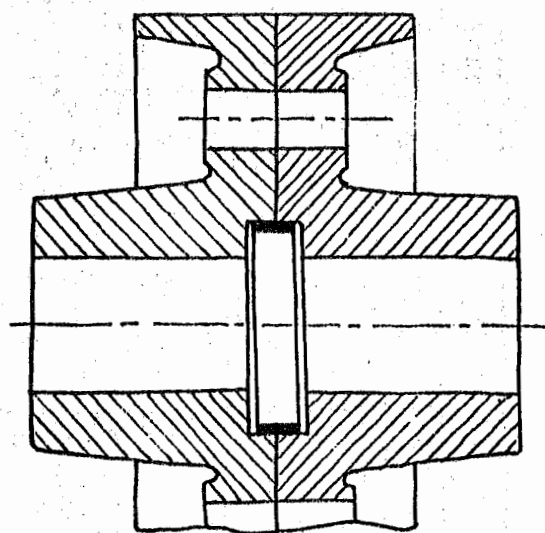
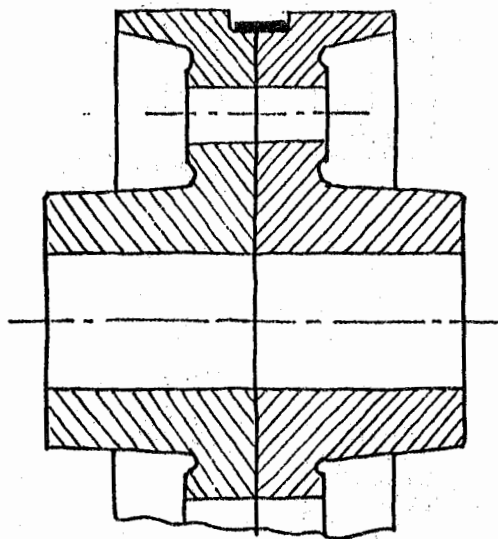
$$\text{Total friction torque required} = 1.5 * T_d$$

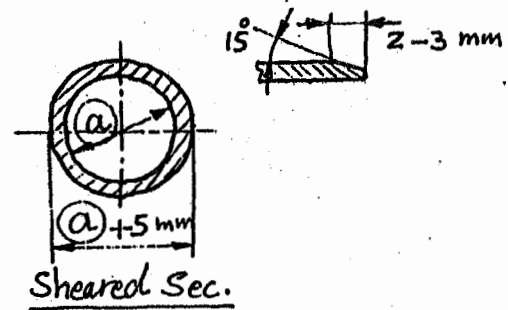
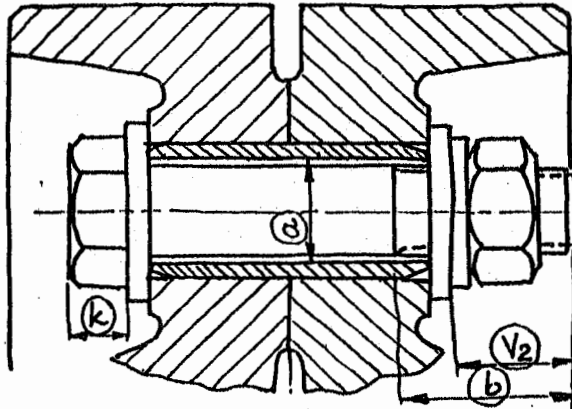
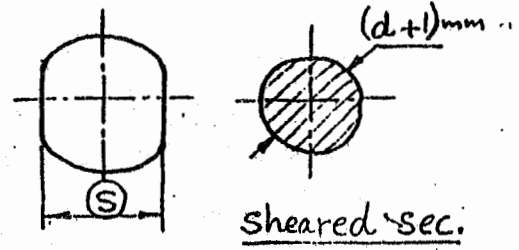
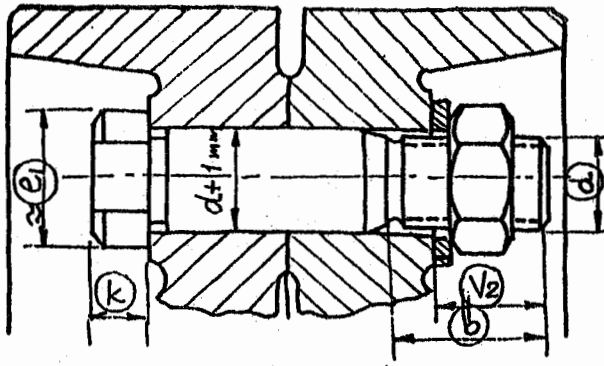
(the factor 1.5 is called a security factor.)

$$\text{Total friction force} = \frac{1.5 * T_d}{(D_{fr}/2)} = F_{fr}$$

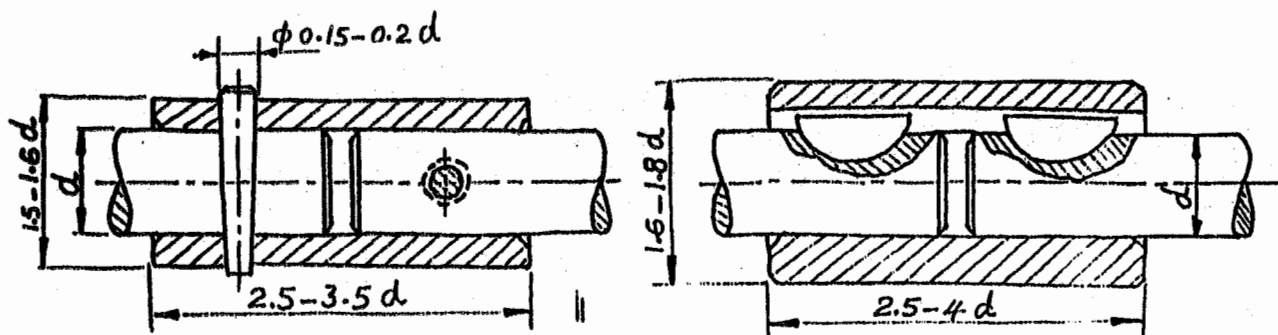
$$\text{d) No of bolts} = F_{fr} / (\mu_f \cdot P_a)$$

Also : the number of bolts should be divisible by 2 (or 3)

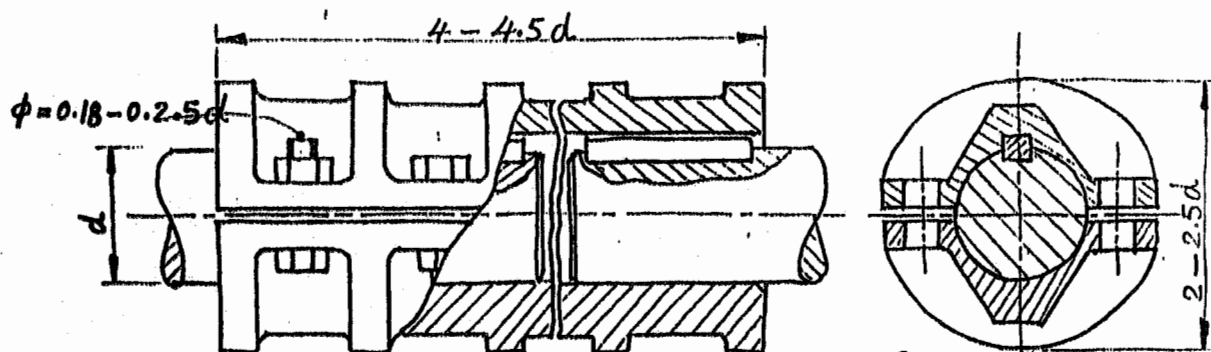




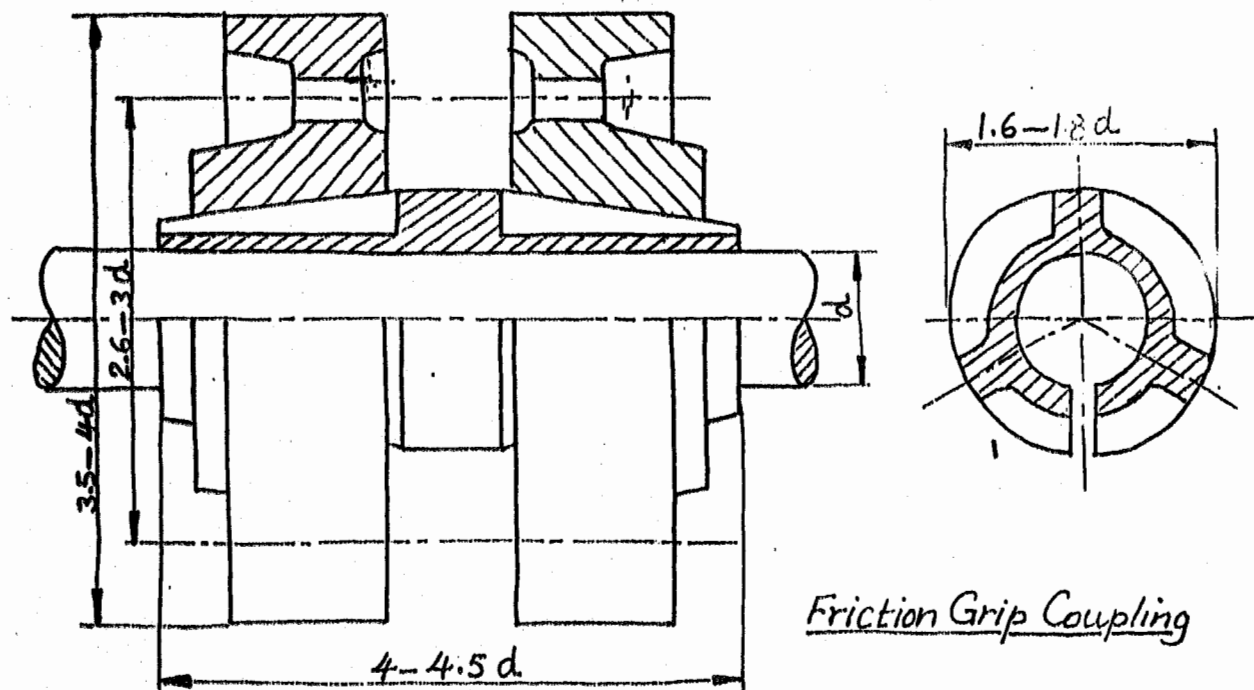
* Encircled dims. to be extracted from tables of standards.



Sleeve Couplings

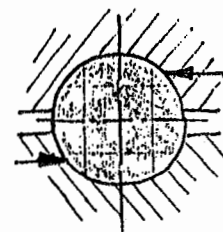
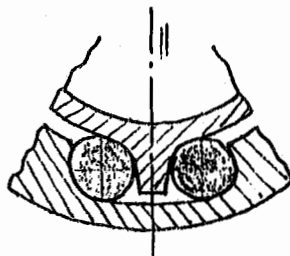
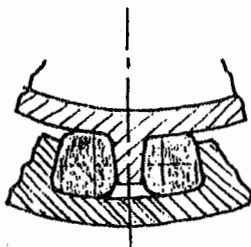
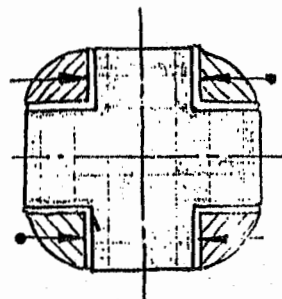
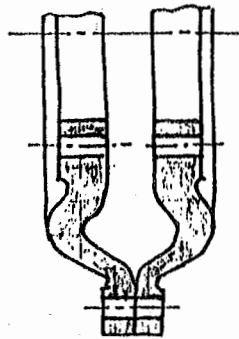
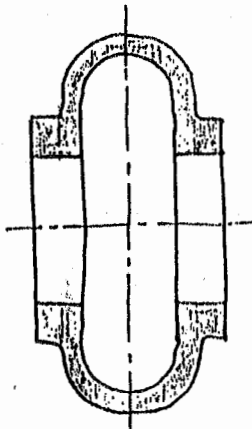
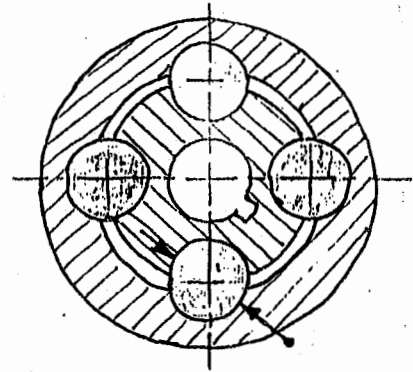
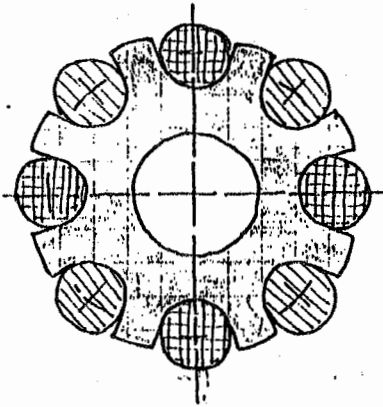
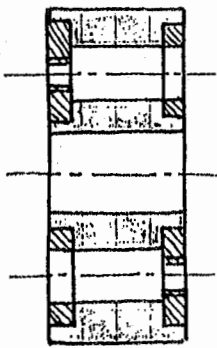
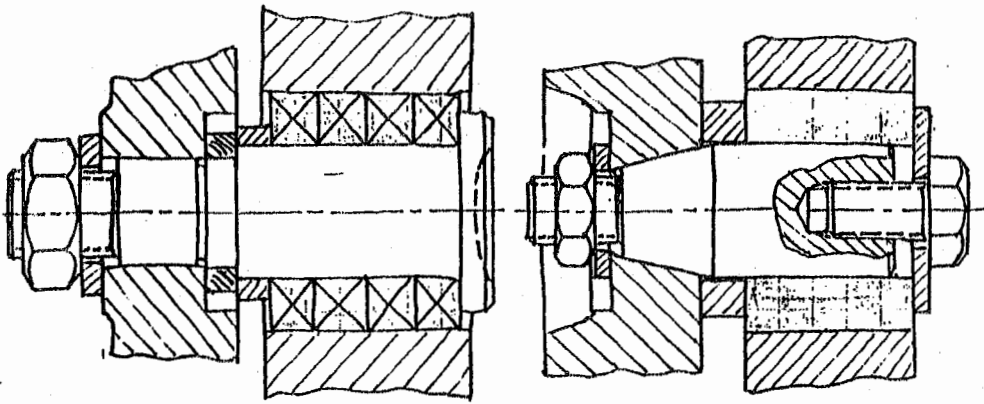


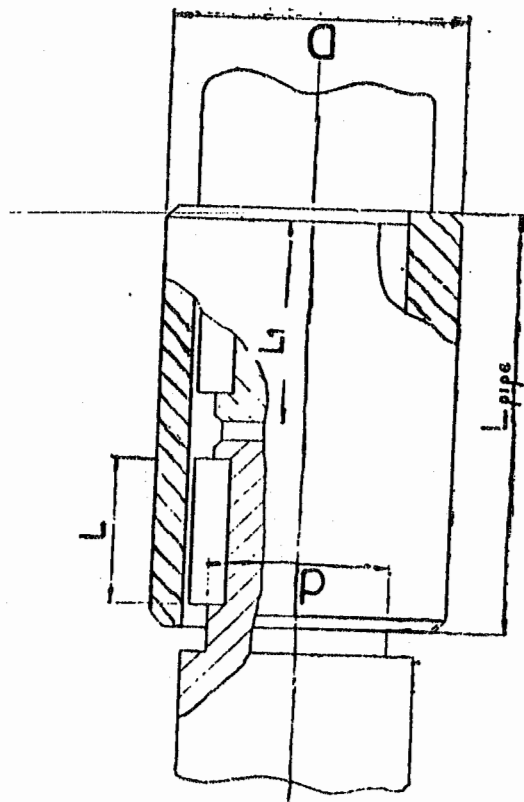
Clamp Coupling



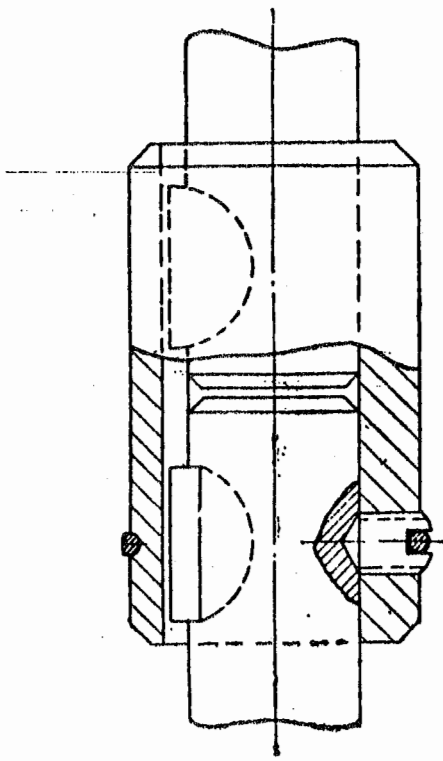
Friction Grip Coupling

RIGID Couplings

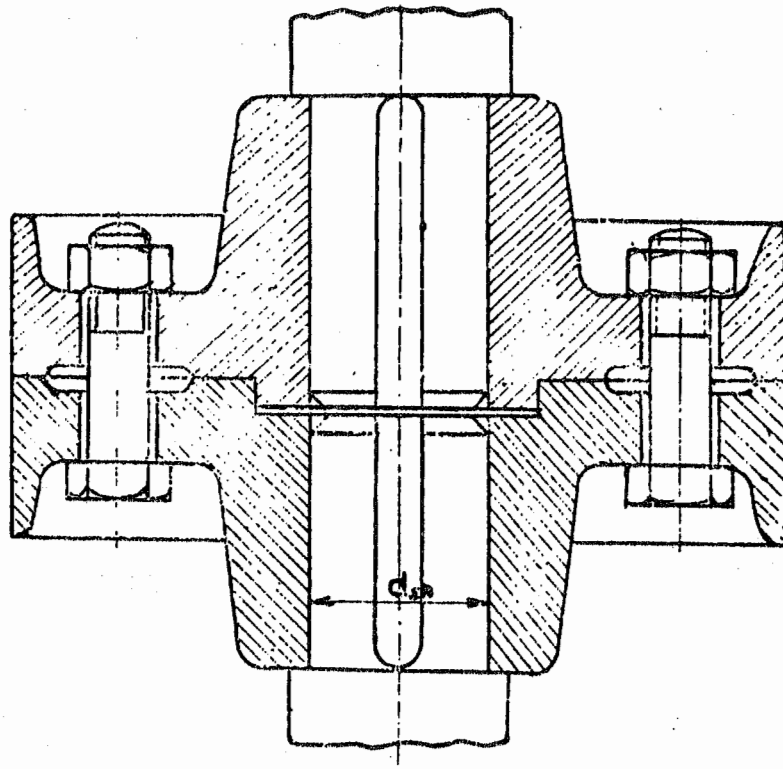




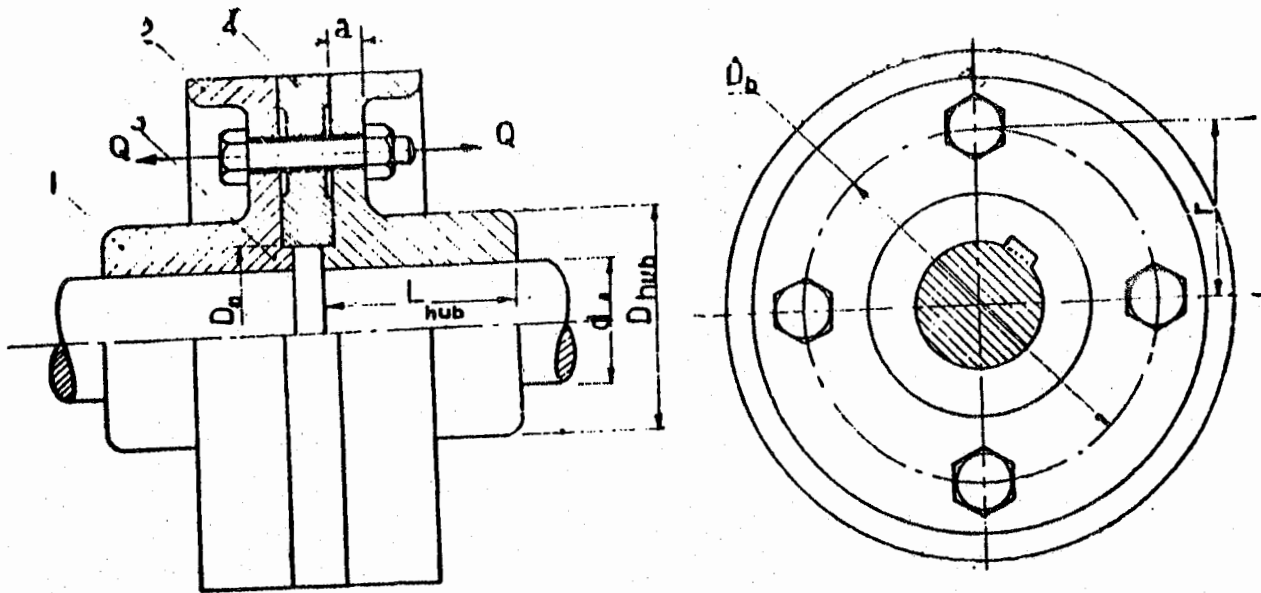
Rigid coupling with feather key



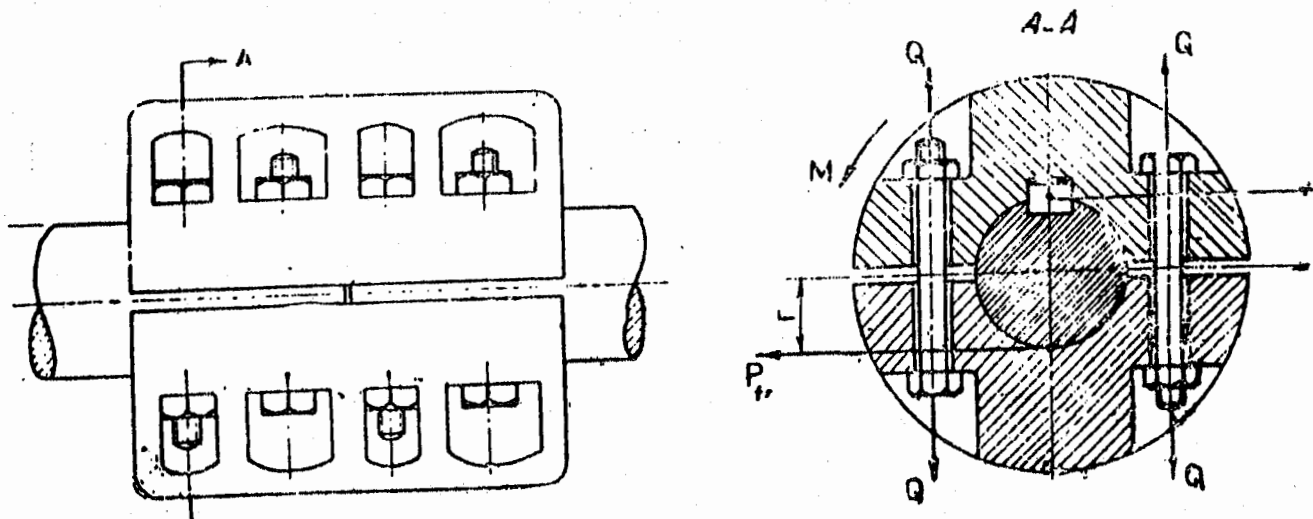
Rigid coupling woodruff



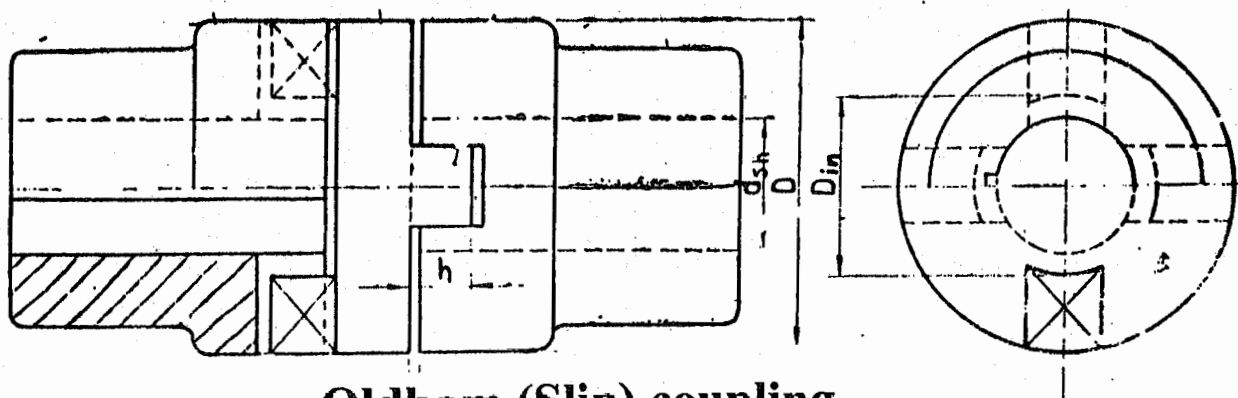
Rigid flange coupling



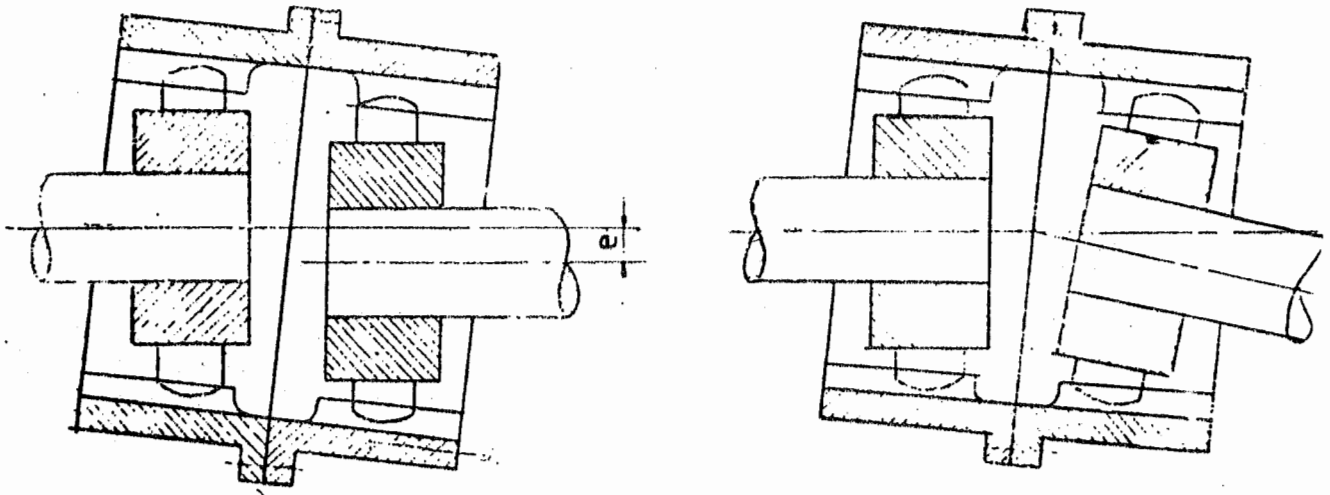
Friction disk rigid coupling



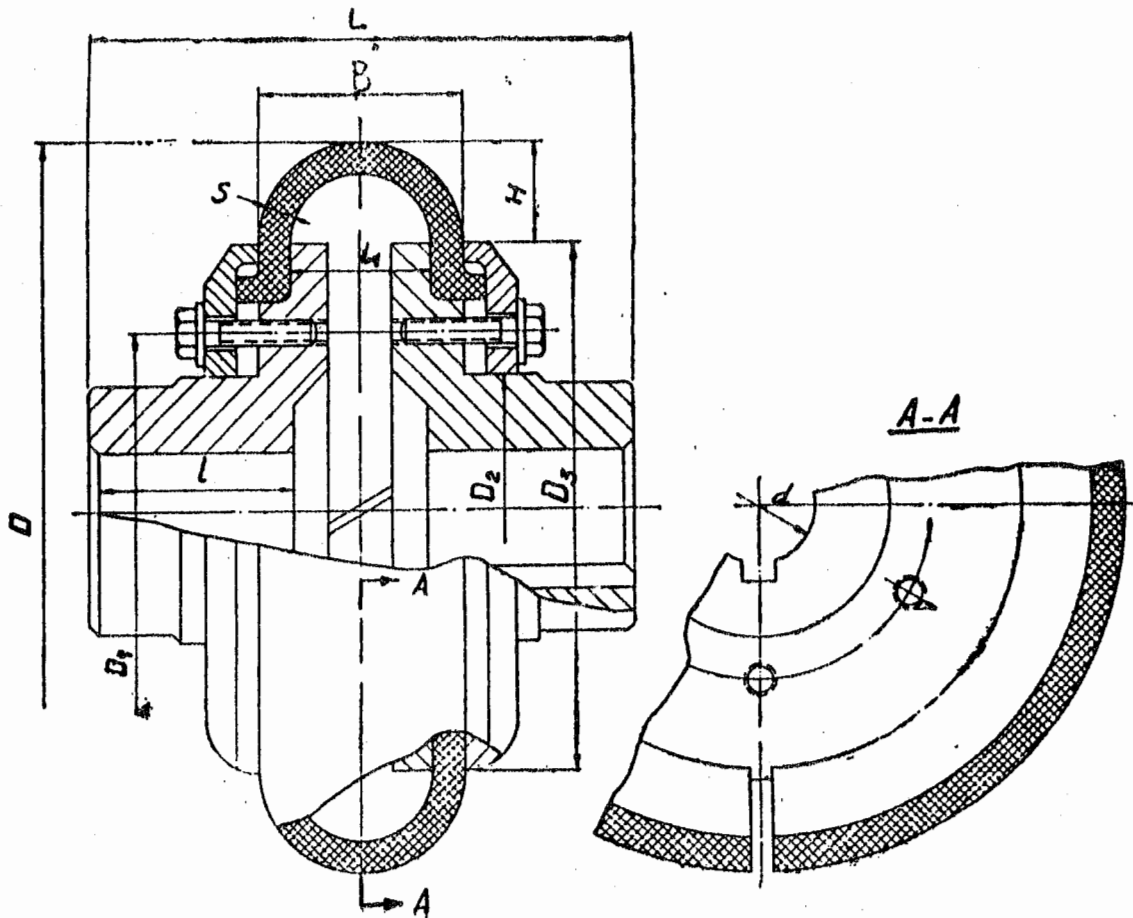
Friction grip coupling



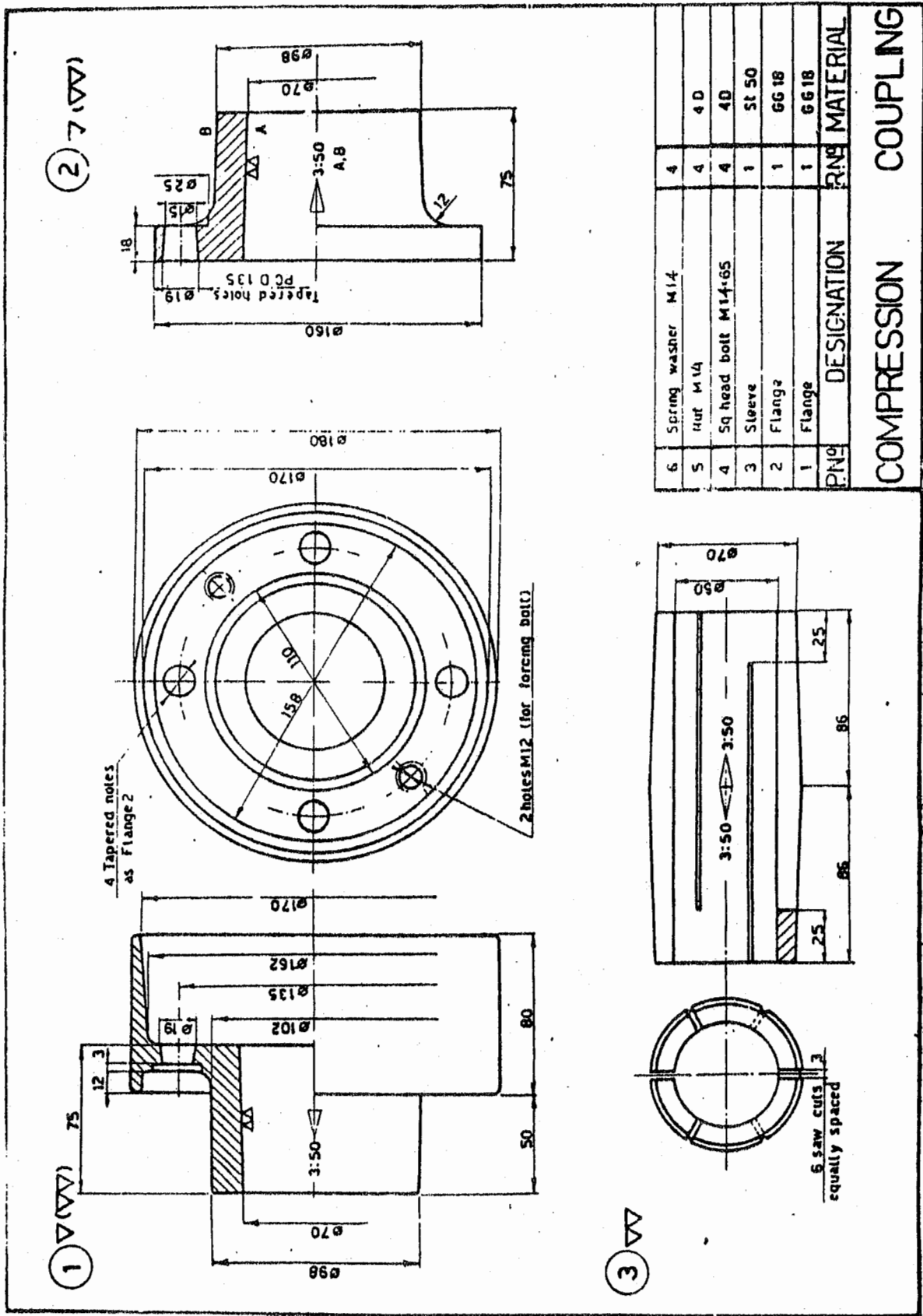
Oldham (Slip) coupling

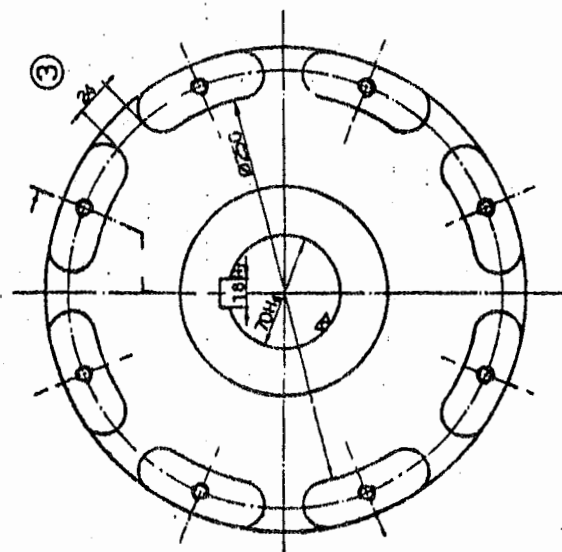
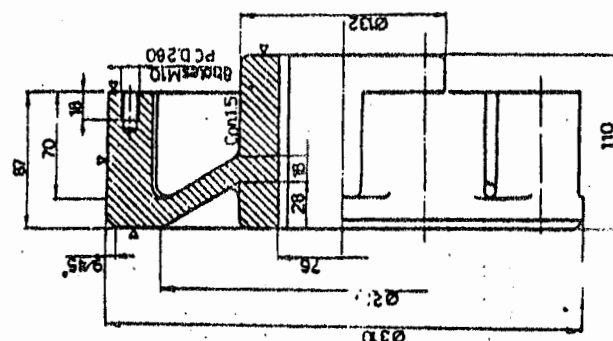
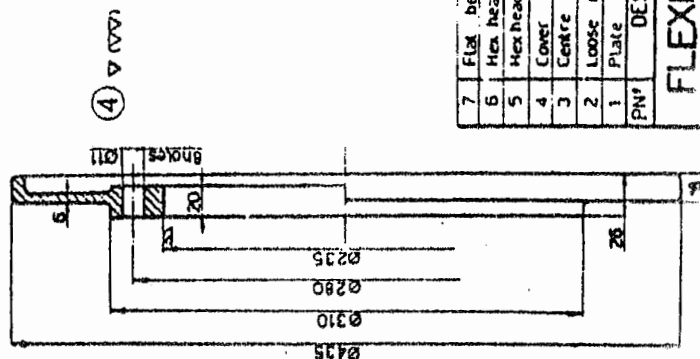
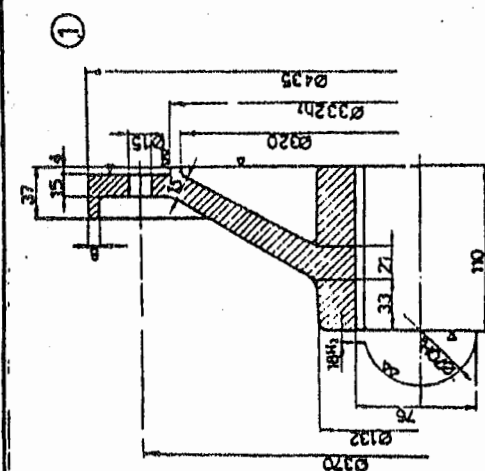


Flexible coupling



Flexible coupling with rubber tire





PN ¹	DESIGNATION	RN ²	MATERIAL
7	Flat bolt 60x6L 3530	1	Leather
6	Hex head screw M10x35	8	40
5	Hex head bolt M14x55	8	40
4	Cover plate	1	65 22
3	Centre frame	1	GG 22
2	Loose ring	1	66 22
1	Plate	1	GG 22

FLEXIBLE COUPLING

1221 6790 1

